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PROVISIONAL INTELLIGENCE REPORT

PETROLEUM IN THE SOVIET BLOC

CIVIL CONSUMPTION OF PETROLEUM PRODUCTS IN THE USSR

CIA/RR PR-17 (I-F)

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Note

The data and conclusions in this report do not necessarily represent the final position of ORR and should be regarded as provisional only and subject to revision. Additional data or comments which may be available to the user are solicited.

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CONFIDENTIALFOREWORD

This report is one of a series of provisional reports pertaining to petroleum in the Soviet Bloc. The entire series is intended to cover all phases of petroleum, natural gas, and synthetic liquid fuels in the Soviet Bloc. These reports are presented as an intermediate step in consolidating pertinent intelligence on the subject and not as a finished study. In the consolidation of the available information, various reports and documents representing research by other intelligence agencies were utilized along with the results of research and analysis by members of the staff of CIA.

It is intended that this series of reports will serve the following purposes:

- a. Represent a base for contributions and additions by CIA and other agencies actively interested in petroleum intelligence.
- b. Facilitate the selection of the specific and detailed gaps in intelligence warranting priority attention.
- c. Provide the basis for a broad study on petroleum in the Soviet Bloc and various studies directed toward specific critical problems.

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CIVIL CONSUMPTION OF PETROLEUM PRODUCTS IN THE USSRSummary and Conclusions

The estimated consumption by the civilian economy of the USSR of various petroleum products for the years 1950-1953 are shown in Table 1. Estimates are presented for the peacetime calendar years of 1950, 1951, 1952, and Fiscal 1953 (1 July 1952 - 30 June 1953). In addition, estimates are presented of the minimum essential civilian requirements for petroleum products by the Soviet economy during Fiscal 1953 in event of a major war.

TABLE 1. Estimated Consumption of Petroleum Products by the
Civilian Economy of the USSR
1950-1953

	Million Metric Tons				
	Peace			War	
	1950	1951	1952	Fiscal 1953	Fiscal 1953
Gasoline and Ligroins	8.1	9.1	10.4	11.0	7.7
Kerosene	5.3	5.3	5.2	5.1	4.0
Diesel Oil	3.3	3.7	4.3	4.5	4.0
Fuel Oil	11.4	12.5	13.2	13.7	11.1
Lubricants	2.2	2.3	2.6	2.7	2.2
Total	30.3	32.9	35.7	37.0	29.0

Table 1 summarizes by products the estimates which have been made of the consumption of petroleum products by the major petroleum consuming sectors of the Soviet economy. The consumption by each of these sectors by years is presented in the Tables 2 through 6 below. Detailed analyses of the consumption of each petroleum consuming sector of the economy are presented in parts 1 through 7 of this report.

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TABLE 2. Estimated Consumption of Petroleum Products by Components
of the Civilian Economy of the USSR
1950 (Peace)

	Million Metric Tons					
	Gasoline & Ligroine	Kerosene	Diesel Oil	Fuel Oil	Lubricants	Consumption by groups as of % of total
Motor Transport	5.6	-	-	-	.3	19.5
Agriculture	1.6	3.4	1.5	-	.5	23.1
Shipping	-	-	.5	1.2	.1	5.9
Railroads	-	-	.1	1.8	.1	6.0
Industry	.5	-	1.2	8.4	1.2	37.3
Home	-	1.9	-	-	-	6.3
Air Transport	.4	-	-	-	-	1.3
Total	8.1	5.3	3.3	11.4	2.2	100.0

TABLE 3. Estimated Consumption of Petroleum Products by Components
of the Civilian Economy of the USSR
1951 (Peace)

	Million Metric Tons					
	Gasoline & Ligroine	Kerosene	Diesel Oil	Fuel Oil	Lubricants	Consumption by groups as of % of total
Motor Transport	6.6	-	-	-	.3	21.0
Agriculture	1.6	3.4	1.8	-	.5	22.1
Shipping	-	-	.5	1.2	.1	5.5
Railroads	-	-	.1	1.8	.1	6.1
Industry	.5	-	1.3	9.5	1.3	38.3
Home	-	1.9	-	-	-	5.8
Air Transport	.4	-	-	-	-	1.2
Total	9.1	5.3	3.7	12.5	2.3	100.0

TABLE 4. Estimated Consumption of Petroleum Products by Components
of the Civilian Economy of the USSR
1952 (Peace)

	Million Metric Tons					
	Gasoline & Ligroine	Kerosene	Diesel Oil	Fuel Oil	Lubricants	Consumption by groups as of % of total
Motor Transport	7.8	-	-	-	.4	23.0
Agriculture	1.5	3.3	2.1	-	.5	20.7
Shipping	-	-	.6	1.2	.1	5.3
Railroads	-	-	.1	1.8	.1	5.6
Industry	.6	-	1.5	10.2	1.5	38.7
Home	-	1.9	-	-	-	5.3
Air Transport	.5	-	-	-	-	1.4
Total	10.4	5.2	4.3	13.2	2.6	100.0

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TABLE 5. Estimated Consumption of Petroleum Products by Components
of the Civilian Economy of the USSR
Fiscal 1953 (Peace)

	Million Metric Tons					Consumption by groups as % of total
	Gasoline & kerosene	Kerosene	Diesel Oil	Fuel Oil	Lubricants	
Motor Transport	8.4	-	-	-	.4	8.8
Agriculture	1.5	3.2	2.3	-	.6	7.6
Shipping	-	-	.6	1.2	.1	1.9
Railroads	-	-	.1	1.8	.1	2.0
Industry	.6	-	1.5	10.7	1.5	14.3
Home	-	1.9	-	-	-	1.9
Air Transport	.5	-	-	-	-	.5
Total	11.0	5.1	4.5	13.7	2.7	37.0
						100.0

TABLE 6. Estimated Consumption of Petroleum Products by Components
of the Civilian Economy of the USSR
Fiscal 1953 (War)

	Million Metric Tons					Consumption by groups as of % of Total
	Gasoline & kerosene	Kerosene	Diesel Oil	Fuel Oil	Lubricants	
Motor Transport	5.9	-	-	-	.3	6.2
Agriculture	1.3	3.0	2.1	-	.5	6.9
Shipping	-	-	.6	1.1	.1	1.8
Railroads	-	-	.1	1.8	.1	2.0
Industry	.5	-	1.2	8.2	1.2	11.1
Home	-	1.0	-	-	-	1.0
Air Transport	-	-	-	-	-	-
Total	7.7	4.0	4.0	11.1	2.2	29.0
						100.0

The methods used in this report to estimate the petroleum product consumption of various sectors of the economy are different for each sector. It is believed that the best method currently possible, in the light of available information, has been used in each case. In several cases, new methods of estimation have been devised. In others, it has only been possible to refine slightly the methods used in earlier reports. In still other cases, it has not been possible to improve on previous estimates.

In every case, attention has been devoted to determining the degree of error which may be possible in the estimate. Where possible, the range of error of the

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estimate has been indicated. Where this has not been possible, some indication has been given of the degree of confidence which may be placed in the estimate.

In general it will be found that the degree of error which is anticipated in the estimates is quite large. This is due to the fact that consumption estimates must be assembled from a variety of secondary estimates. Even in the area of secondary estimates data are often lacking; it is therefore often necessary to make incompletely substantiated assumptions. The present report attempts to synthesize the current state of knowledge about consumption of petroleum products in the USSR. Where knowledge is currently inadequate, it has been indicated to be so.

As a guide to the degree of confidence which may be placed in the estimates presented in Tables 1 to 6, the following summaries of the analyses of consumption by various sectors of the economy is included:

Motor Transport. Gasoline consumption by civil motor transport has been derived by a method in which 1936 gasoline consumption per ton kilometer of motor freight is used in conjunction with current statistics on ton-kilometers of motor freight to obtain current consumption. The resultant estimates are believed to have an upward bias. It has not been possible to estimate the degree of bias. Wartime gasoline requirements for motor transport are estimated to be 25% less than peacetime consumption. This deep a cut is believed possible without affecting the ability of the Russian economy to support a war; a deeper cut might perhaps be possible. The estimates of diesel fuel and lubricant consumption are considered less reliable than the gasoline estimate.

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Agriculture. Consumption estimates are based on estimates of the composition and horsepower of the Soviet tractor park, used in conjunction with prewar annual unit fuel consumption rates. The total consumption of liquid fuels, and the consumption of diesel fuel, are considered more reliable estimates than those of gasoline (including ligroine), and kerosene. Wartime requirements for tractor fuel of all types have not been cut very substantially, since it is believed that the USSR would need to maintain current levels of agricultural production in wartime. The lubricating oil consumption estimates are tentatively derived as a factor of fuel consumption.

Shipping. A tripartite analysis of shipping requirements has been made, dealing separately with the consumption of the deep sea fleet, the Caspian fleet, and the inland waterways fleet. In each case, the analysis is based on estimates of the composition and use of the units of the fleet concerned, together with fuel consumption rates based on consumption per horsepower hour. Data on the deep sea fleet, which makes up the largest part of the total shipping requirement for petroleum products, are sufficient to insure reasonable confidence in this estimate. Less current information is available on the Caspian fleet, so that this estimate is more questionable. The estimate of river fleet consumption is entirely tentative. Fortunately, the volume of petroleum required by the river fleet is also thought to be the smallest. The overall consumption estimates for shipping are therefore not believed to be subject to great error. Wartime requirements of Soviet shipping are estimated to be about the same as in peacetime. The

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validity of this estimate depends on assumptions with regard to the nature of the war involved, and with regard to the degree of Allied control over the seas contiguous to the USSR.

Railroads. Three methods of analysis are presented to support the conclusion that railroad fuel oil consumption is smaller than has previously been considered. The range of the estimates is wide, and it is, therefore, not practical to pinpoint consumption of fuel oil with less than a $\pm 50\%$, $\pm 10\%$ possible error. The East Austrian and US data on which lubricating oil consumption estimates are based appear to be more satisfactory than those available for previous reports. Diesel fuel and kerosene consumption is small, so that the relatively large possible error to which these estimates are subject is not overly important. No important reduction from peacetime levels is expected in wartime railroad requirements for petroleum products.

Industry. All fuel oil which remains to the USSR after the fuel oil requirements of the Soviet Navy, shipping, and the railroads are subtracted from total availability of fuel oil, is considered to be available to industry. In addition, the crude oil consumed as fuel in the oilfields has been taken into account in preparing this estimate. The accuracy of this estimate, therefore, depends on the degree of error which may be present in the component estimates. The overall error is not thought to be very large. The importance of an error in this calculation is reduced since it is thought that fuel oil is the least critical petroleum product. This is due to the substitutability of other fuels for fuel oil. The wartime estimate of industrial fuel oil requirements is constructed in the same manner. A much more serious problem is raised by industrial requirements for diesel fuel, gasoline, and

lubricants. The present estimates of the industrial consumption of these products are little more than directionally correct guesses. Further research is in progress which may permit improvement of these estimates.

Home Use. The industrial and home use of kerosene are considered together in this estimate, since it has been impossible to separate the two demands. The estimate presented is based on the trends of prewar consumption of this product, which indicate that present consumption is probably limited to about the levels of production planned for 1941. The degree of error thought to be present is $\pm 25\%$. Wartime requirements for kerosene for home and industrial use have arbitrarily been cut 50% below the peacetime levels of consumption. This estimate is only thought to be accurate within the limits of a $\pm 25\%$ error. It is not considered that there is any important home requirement for products other than kerosene.

Air Transport. The consumption of aviation grade gasoline is based on estimates of the composition of the Soviet civilian air fleet. The annual use of the aircraft, and their fuel consumption rates. The small size of the requirement suggests that the absolute error possible cannot be very great. Wartime requirements for civilian air transport are thought to be negligible, since the aircraft concerned will probably be transferred to the military in wartime.

An analysis is presented in the last columns of Tables 2 through 6 of the relative importance of each consuming sector of the Soviet economy. It will be noted that over 75% by weight of the products consumed are accounted for by motor transport, agriculture, and industry. Of these three, industry is the largest

consumer. The critical importance of industry as a consuming group is lessened, however, by the fact that the majority of industrial demand is for fuel oil.

Motor transport and agricultural requirements, on the other hand, consist largely of demand for light products and middle distillates.

The consumption of petroleum products by motor transport is seen to be increasing throughout the period, rising from 19.5% of total consumption in 1950 to 23.8% in Fiscal 1953. In wartime motor transport is estimated to account for approximately the same percentage of total consumption as in peacetime: 21.4% of total civilian requirements. Agriculture, on the other hand, is shown as decreasing in importance in peacetime from 23.1% of the total in 1950 to 20.5% in Fiscal 1953. This is largely accounted for by the increasing number of diesel tractors, which are replacing the less efficient gasoline, ligroine, and kerosene vehicles throughout the period, thereby reducing fuel consumption. In wartime, the relative importance of agriculture is shown by the fact that agricultural petroleum requirements will increase to 23.7% of total civilian requirements. Industrial consumption of petroleum products is seen to be increasing throughout the period, rising from 37.3% of the total demand in 1950 to 38.7% in Fiscal 1953. Industry continues to account for 38.3% of the total civilian consumption in wartime.

Fluctuations are less apparent and less important among the minor consuming groups. It should be pointed out that home consumption of petroleum products accounts for progressively smaller percentages of total consumption throughout the period. Another item of interest is that railroad and shipping consumption accounts for a larger percentage of total requirements in war than in peace. As has been indicated, air transport requirements in war disappear because the aircraft are considered to be turned over to the military.

I. Consumption of Petroleum Products by Motor Transport.

Summary.

The estimated consumption of petroleum products by civilian motor transport in the USSR is presented in Table 7. These estimates have been prepared in accordance with a method of estimation which makes direct use of available Russian statistics on the work performed by Soviet civil motor transport.

TABLE 7. Estimated Consumption of Petroleum Products
by USSR Civilian Motor Transport
1950 - 1953

	Million Metric Tons				
	Peace			War	
	1950	1951	1952	Fiscal 1953	Fiscal 1953
Gasoline	5.6	6.6	7.8	8.4	5.9
Diesel Oil	a/	a/	a/	a/	a/
Lubricants	.3	.3	.4	.4	.3
Total	5.9	6.9	8.2	8.8	6.2

a/ Negligible.

The estimates of gasoline consumption presented above are lower than those included in previously published consumption studies. It is nevertheless believed that these estimates may still have some upward bias, and should be regarded as maximum probable consumption estimates. The possible error involved in these estimates is still quite large; however, it is felt that the method used contains fewer sources of possible error than is the case in other methods.

No consumption of diesel fuel is shown above, since it is believed that civilian diesel fuel requirements for motor transport are negligible. The lubricating oil consumption shown is derived as a percentage of gasoline consumption and is, therefore, subject to the possible errors present in the gasoline estimates, in addition to other possible error.

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Wartime requirements of gasoline for civil motor transport are only a reasoned guess as to the reduction which would be possible in civilian motor gasoline consumption without materially affecting the ability of the economy to support a war. The present state of our knowledge does not permit a more satisfactory solution to this critical problem.

a. Consumption of Gasoline.

A survey has been made of previous methods used to estimate the gasoline consumed by motor transport in the USSR. The approach which has been taken to this problem in the past is that of estimating motor transport gasoline consumption by combining estimates of the size and composition of the civilian motor park, the utilization of the various types of vehicles in the motor park, and the fuel consumption rates of these vehicles.

The difficulties encountered in using this method are considerable. The validity of the final estimate depends on the degree of accuracy possible in each of the secondary estimates on which it is based. It is in the area of these secondary estimates that the most difficulty arises in obtaining reliable data. It will be recognized that accurate data on the present size and composition of the Soviet civilian motor park are not readily available. Information on the present utilization of various types of vehicles in the motor park is particularly hard to obtain. The lack of precise current data in this, and in other secondary estimates, makes it necessary to rely on reasonable assumptions, if this approach is to be used. While the possible error which may be introduced by any one assumption may be small, it is apparent that the use of a number of assumed variables in a long calculation can result in a compound possible error of considerable proportions. The size of the possible error becomes increasingly more difficult to determine as the complexity of the calculation increases.

Another approach to the problem has been attempted in this report. The present method has the advantage of being able to make direct use of the most recent Soviet statistics on the volume of motor transport in the USSR. It is recognized that the present method of approach is still subject to considerable possible error; however, it is believed that the error possible in this method is no greater than that which would be possible in the older approach.

The present method relates volume of motor freight in ton-kilometers to gasoline consumption by motor transport. The relationship which has been set up may be expressed as follows:

$$\frac{\text{Motor Freight (in ton-kilometers) in a known year}}{\text{Gasoline consumption of motor transport (in tons) in the same known year}} = \frac{\text{Motor Freight (in ton-kilometers) in year "x"}}{\text{Gasoline consumption of motor transport (in tons) in year "x"}}$$

It has been possible at this writing to determine the relationship between motor freight volume and motor transport gasoline consumption in only one known year - 1936. The possibilities of error which are introduced into the calculation as a result of using a relatively old base year are discussed at some length in subsequent paragraphs of this report. For the moment, it should be pointed out that if it is possible to establish an acceptable base year, it follows that published and calculable Russian statistics on volumes of motor freight may be substituted into the right hand side of the above equation to obtain motor transport gasoline consumption directly.

The data given in Table 8 are available on motor freight transport in the USSR. The volumes of motor freight are expressed by Soviet statisticians in ton-kilometers. It may be well to explain the meaning of ton-kilometer statistics. The weight of each recorded freight shipment in metric tons is multiplied by the particular distance which

that shipment travels in kilometers. By totaling the results of this calculation for each recorded shipment in a year, total ton-kilometers per year is derived. The data for the years 1928 through 1950 are either published Russian data, or are calculated directly from these data. 1951 through 1953 data are estimated. A detailed discussion of the derivation of these data is included in the Annex. 1/

TABLE 3. Motor Freight Traffic in the USSR
1928-1953

<u>Year</u>	<u>Billion Ton Kilometers</u>
1928	.1
1929	.2
1932	1.1
1933	1.4
1937	8.0
1940	8.9
1941 Plan	9.4
1945	4.4
1946	6.4
1947	10.8
1948	13.3
1949	17.0
1950 Plan	25.0
1950 Actual	20.1
1951 (Est.)	23.7
1952 (Est.)	28.0
Fiscal 1953 (Est.)	30.5

In order to be able to use these data, it is necessary to establish a base year.

In this report, it was decided to use 1936, since this is the last year in which motor gasoline consumption by motor transport is known. In that year, gasoline consumption by motor transport was 1,720,000 metric tons: 1,170,000 metric tons for non-agricultural motor transport, and 550,000 metric tons for motor transport in agriculture. 2/

The gasoline consumption data for 1936 is therefore established. There remains to determine that volume of motor freight transported in that year. It will be noted that 1936 is not one of the years in which a direct datum on ton-kilometers of freight is available. It must then be calculated.

Footnote references in arabic numerals are to sources listed in the Annex.

Ton-kilometers of freight in 1937 is known to be 8.0 billion ton-kilometers. It is possible to estimate 1936 ton-kilometers from this figure.

The 1937 truck inventory of the Soviet Union is known, as is that for 1936. 1936 traffic might, therefore, be estimated in accordance with the following ratio:

$$\frac{1936 \text{ Freight}}{1936 \text{ Truck Inventory}} = \frac{1937 \text{ Freight}}{1937 \text{ Truck Inventory}}$$

This would be satisfactory if the utilization of the truck inventories were the same in 1936 as in 1937. However, it is known that the utilization of the vehicle inventory in 1937 was lower than in the preceding five years.

TABLE 9, 3/ showing the work of Soviet trucking organizations with 10 or more vehicles, points up this fact.

TABLE 9. Work Statistics of Soviet Trucking Organizations
1932 - 1937

	Actual							Plan 1937
	1932	1933	1934	1935	1936	1937	1937 4th quarter	
No. of vehicles leaving for work each day as a percent of the total registered	48	56	57	56	56	47.6	46	75
Average daily loaded (in kilometers)	75	65	74	67	68	69	61	90

The severe drop in the percentage of vehicles working each day in 1937 is explained in the source, and in other articles in the Soviet press, as being due to shortages of tires and tubes, spare parts, repair stations, repair personnel, and funds for repairs. This drop would have an immediate effect on traffic.

TABLE 9 shows an insufficient increase in the average daily loaded run to have offset the decrease in the number of units utilized. Consequently, in making the 1936 traffic estimate, the data have been weighted by the average yearly percentage of truck inventory leaving for work, taken from Table 9.

Year end truck inventories are known to have been 201.2, 315.5, and 471.5 thousands of vehicles in 1935, 1936, and 1937. 4/ From this, it may be calculated that mid-year inventories amounted to 258.4 and 395.0 thousands in 1936 and 1937. 5/

The calculation of 1936 ton-kilometrage is, therefore, as follows:

Let x = 1936 traffic

$$\frac{x}{.56 (258.4)} = \frac{8.0}{.476 (395.0)}$$
$$x = 6.2$$

1936 traffic is, therefore, calculated to be 6.2 billion ton-kilometers, which seems to be consistent with data from prior and succeeding years. Thus, the datum for the 1936 base year has now been derived. Substituting this datum into the left hand side of the basic equation, and the data from Table 8, into the right hand side, it is possible to arrive at the estimates of gasoline consumption shown in Table 10.

TABLE 10. Calculated Gasoline Consumption by Soviet
Motor Transport, 1936-1953

Million Metric Tons

Year	Gasoline Consumption
1936	1.72
1937	2.2
1940	2.5
1941 (Plan)	2.6
1945	1.2
1946	1.8
1947	3.0
1948	3.7
1949	4.7
1950 (Plan)	6.9
1950	5.6
1951	6.6
1952	7.8
Fiscal 1953	8.4

A discussion of the error possible in these estimates is in order. The error which is inherent can stem from two major sources: (1) changes in the conditions

of motor transport since the base year (in this case, 1936) which will distort the results of the calculation; and (2) errors in the statistics used to complete the calculation.

(1) Errors Due to Changes in the Conditions of Motor Transport since 1936.

(a) It will be noted that the basic data on gasoline consumption in 1936 did not specify whether or not gasoline used for passenger transport was included, or what the amount of gasoline involved in passenger transport might be. It is believed, however, that gasoline for passenger transport was included in the 1,720,000 metric tons of gasoline cited. It is plain that if passenger gasoline is included in this figure, a ratio has been established between freight traffic (which excludes passenger traffic) and gasoline consumption by both freight and passenger traffic, in the base year. This could lead to serious distortion in the results of the equation if the amount of passenger gasoline consumption was large, or if the amount of passenger gasoline consumption varied in disproportionate manner to freight gasoline consumption. It is not believed that any substantial volume of passenger traffic or gasoline consumption could have been present in 1936. Moreover, it is believed that passenger traffic currently accounts for only a very small part of total traffic, since the USSR has continued to emphasize truck production in later years. It is therefore considered that this is not an overly important source of error.

(b) The gasoline consumption data for the base year 1936 includes gasoline for both agricultural and non-agricultural motor traffic. It is possible that in later years there might have been a disproportionate variation in the amounts of

agricultural and non-agricultural traffic. Such a variation could induce distortions; however, insufficient data are available at this writing to be able to determine whether this error would be important.

(c) Another change in conditions which might make the results of the equation less reliable would be a percentage increase in the number of non-gasoline consuming vehicles in the truck and car park of the USSR. These vehicles would include gas generating vehicles, liquified petroleum gas burning vehicles, and diesel powered vehicles. The use of all these types of vehicles was negligible in 1936. In later years, this is not the case. However, it is believed that this type of vehicle accounted for less than 2% of the civilian motor park in 1950, and carried less than 2% of the traffic. While it is believed that the Soviet has been producing diesel trucks, it is thought that most of these trucks are turned over to the military. The degree of error induced by this change in conditions is, therefore, thought to be limited to about 2%.

(d) In the right hand side of the basic equation, a rate has been established which determines gasoline consumption per ton-kilometer of freight traffic in 1936. This can be calculated to be $\frac{1,720,000}{8,200,000,000}$, or .0002774 metric tons of gasoline per ton-kilometer of freight traffic. The equation, in effect, states that gasoline consumption per ton-kilometer in 1936 times the number of ton-kilometers of freight in a later year will give the gasoline consumption in that later year. This reasoning is subject to some error. It is apparent that gasoline consumption per ton-kilometer, as between any two years, can be affected by numerous conditions. These conditions concern, principally, the status of automotive tech-

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nology, the status of fuel technology, the condition of the road-net, and the training and skill of transportation workers. It is plain that in the short run none of these conditions would change drastically enough to alter seriously the average amount of gasoline consumed per ton-kilometer of freight traffic. However, there has been a consistent improvement in the vehicles produced in the USSR since 1936. At the same time, some improvement has been made in the gasoline available. Also, it is assumed that the skill of workers in the motor transport system of the USSR has increased. Finally, Soviet roads have been improved consistently. It is clear, then, that over the long run, gasoline consumption per ton-kilometer of freight should be decreasing in the USSR. The use of 1936 unit consumption rates for long run estimates will therefore result in error. The direction of the error is known; the equation will result in long run estimates which are too high. Unfortunately, the degree of error cannot be calculated at this time. The long-run estimates which result from the equation should, however, have one advantage: they should indicate the maximum probable gasoline consumption in the years concerned. No attempt has been made to reduce the estimates presented for 1950-53 to allow for this error, since the degree of error is unknown.

(2) Errors in Statistics Used in the Calculations.

(a) The degree of accuracy of Russian traffic statistics may perhaps be questioned. It is particularly pertinent to speculate about the degree of traffic coverage which existed in the USSR in 1937, as compared to later years. If the

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coverage were more complete in later years than in 1937, it is apparent that the use of 1936 (derived from 1937 data) as a base year would result in the estimates for later years being too high. There is no way at this time of determining the relative accuracies of Soviet traffic data.

(b) The 1936 figure for gasoline consumption may only be a close approximation of the actual figure. It has not been possible to find a second Soviet source to check the figure of 1,720,000 metric tons. However, the source of the data is an article in the official journal of the State Planning Commission. The data should be as good as any which a Soviet official could derive from data available to him. Maximum possible error in this figure should be about $\pm 10\%$.

(c) The estimate of 1936 traffic used may be wrong due to errors in the method of estimating this figure from 1937 data. In order to delimit this error, 1936 traffic was calculated in a number of different ways - e.g. constant rate of increase between 1932 and 1937, constant absolute annual increase between 1936 and 1937, constant absolute annual increase between 1936 and 1940, etc. The range of estimate of 1936 traffic was between 5.2 and 7.7 billion ton-kilometers. These figures are taken as the upper and lower limits of possible error, indicating an error of plus 24%, minus 16%.

(d) The figures used for traffic volumes in years after 1936 may be in error. Where these figures are calculated from Soviet percentage factors or from Soviet data, this error should not be very large. In addition, there is some possibility that the Soviet statistics themselves are in error. An overall error of $\pm 10\%$ ought to be sufficient allowance for these errors.

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The above discussion of error should cover most of the potential sources of error in the estimates presented. It will have been noted that the sources of possible error are many, and that the possible errors which are introduced can be either positive or negative. It is believed that on balance, the estimates presented have a positive bias. The intangible nature of the factors which tend to produce this error makes it impossible to measure the possible error in a downward direction. A partial evaluation of the error statistically possible in an upward direction is included in the Annex. 6/

The question of estimating the wartime requirement of civilian motor transport for gasoline presents a knotty problem. In wartime, it may be assumed that some of the trucks in the civilian motor park will be turned over to the military. It may also be presumed that requirements for civilian motor transport for construction activity will disappear as construction decreases in wartime. Any use of motor transport for pleasure will be eliminated in wartime. A certain amount of consolidation in transport requirements may be possible, particularly in the area of transporting agricultural products. Maximum conversion of motor vehicles to gas generating equipment will undoubtedly be effected. All these factors will tend to reduce the wartime gasoline requirement for civilian motor transport. On the other hand, economic activity in wartime will be increased in order to maintain the economic potential necessary to support the war. It is difficult to visualize an extremely deep cut in the consumption of gasoline by civilian motor transport under these conditions. It is not believed that there exists enough "fat" in the Soviet motor transport picture to allow a cut much in excess of 25%. While this

important point is debatable, there is not enough evidence available at the moment to make possible anything more than a reasoned guess. A possible cut of 25% has been arrived at in consultation with personnel from PAD who are generally familiar with the limitations of petroleum rationing in the United States and the Western world. A 25% cut from the 1952 level has therefore been arbitrarily assumed in preparing the wartime estimate for fiscal 1953.

b. Consumption of Diesel Oil.

In line with the assumption that most diesel trucks being produced are turned over to the military, and that diesel trucks account for less than 2% of the civilian motor park, diesel requirements for civil motor transport are considered to be negligible.

c. Consumption of Lubricants.

25X1 In an [] lubricating oil consumption was estimated to be 4% of liquid fuel allocations. Previous [] reports have used a factor 25X1 of 5% by weight of gasoline requirements. The justification for this factor is different in different reports. In this report, it has tentatively been decided to use a 5% factor, subject to further research. The possibility of error in this calculation is thought to be very large. In terms of the overall Soviet requirement for lubricants, this error is important; however, in terms of the total requirements for petroleum products, it is not significant, since the quantity of lubricants involved is very small relative to total product requirements.

2. Consumption of Petroleum Products by Agriculture.

Summary.

Estimated consumption of petroleum products by Soviet agriculture in the period 1950-1953 is presented in Table 11. Included in these estimates are the requirements for fuels and lubricants for tractors, other agricultural machinery, and stationary motors used in farming and the timber industry. Consumption of petroleum products by trucks and automobiles used in agriculture is not included above, but is considered in the section of this report dealing with motor transport. Similarly, consumption of petroleum derivatives used in rural home lighting, heating, and cooking is considered in the section relating to home use.

TABLE 11 - Estimated Consumption of Petroleum Products by
Agriculture in the USSR
1950 - 1953

	Million metric tons				
	1950	1951	Peace 1952	Fiscal 1953	WAR Fiscal 1953
Gasoline	1.6	1.6	1.5	1.5	1.3
Kerosene	3.4	3.4	3.3	3.2	3.0
Diesel Oil	1.5	1.8	2.1	2.3	2.1
Lubricants	.5	.5	.5	.6	.5
Total	7.0	7.3	7.4	7.6	6.9

The majority of the agricultural consumption shown above represents consumption of fuel products by tractors used in farming. The accuracy of the estimates therefore depends largely on the accuracy with which the farm tractor park and its fuel consumption may be estimated. Data are available which permit estimates of total fuel consumption, and of diesel fuel consumption, by the tractor park. Less confidence may be placed in the gasoline (including ligroine) and kerosene consumption estimates. Estimates of consumption of fuel by tractors used in timber extraction, and by other types of agricultural machinery are tentative, as are those of lubricating oil consumption.

With these limitations, total requirements of petroleum products are estimated to increase during peacetime from 7.0 million metric tons in 1950 to 7.6 million

metric tons in fiscal 1953. It will be noted that while this is not a large increase in volume, diesel requirements are estimated to increase throughout the period, both absolutely, and relative to gasoline and kerosene. In wartime 1953, total consumption has been arbitrarily cut back 0.5 million tons from the 1952 level to about the 1950 level. This reduction should be possible with virtually no strain on the Soviet agricultural economy. Deeper cuts might be possible if they were necessary.

Analysis.

Agricultural demand for petroleum products in the USSR is made up almost entirely of the demand for fuel by farm tractors. Before presenting an analysis of the demand for individual products, it is first necessary to estimate the composition and horsepower of the Soviet farm tractor park. Tables 12, 13, and 14, Appendix, present these data.

Table 12 provides estimates of the numerical composition by sources of the Soviet tractor park, 1950-1953. In estimating the number of pre-war tractors remaining in the USSR in 1950, use was made of the known tractor park figure of 523,000 vehicles in 1940. 8/ An estimated 1941 production of 5,500 tractors was added to this figure, 9/ resulting in an estimated tractor population of 528,000 units when the Germans invaded the USSR. 137,000 of these tractors are reported to have been lost during the war. 10/ 391,500 vehicles may therefore be presumed to be the maximum number of pre-war tractors available to the USSR after the war. It is estimated that almost half (47%) of these vehicles will have become inoperative by 1950 as a result of wearing out, or the lack of spare parts. 206,000 pre-war units are therefore estimated to have remained in the Soviet tractor park in 1950. The rate of disappearance of the pre-war units remaining after 1950 is assumed to be increasing, in view of the increasing age of the vehicles.

The attrition rate is estimated to be 40% during 1950, 60% during 1951, and 100% during 1952.

In addition to these prewar vehicles, the USSR is estimated to have acquired an additional 25,000 tractors by requisition, as war booty, or as reparations. By 1950, it is thought that some of the older of these tractors will be inoperative, and that the number of operative tractors from this group will decrease from about 23,000 in 1950 to 14,000 in 1953. The USSR also acquired some 10,000 new tractors under Lend-Lease and from UNRRA, 11/ all of which are assumed to be operative throughout the period considered.

Soviet tractor production was resumed in 1945, and is thought to have totaled 112,000 units through 1948. 12/ All of these units are assumed to be in the effective tractor park through 1952. A 2% attrition rate has then been assumed for these units in 1953. Production of tractors in the years 1949 through 1952 13/ has also been taken into account in preparing the estimates. In addition, the full use equivalent of the tractors produced in each year has been calculated, since it is recognized that not all of the tractors produced in a year require a full year's field allotment of fuel and lubes.

On the basis of these assumptions, the Soviet tractor park has been estimated to decrease from 462,000 units in 1950 to 440,000 units in 1953.

From these data, it is possible to derive the data in Table 13. This table presents annual estimates of the horsepower of the tractor park. In each case, the number of tractors is taken from Table 12. Horsepower per tractor is estimated on the basis of past and present production data, and is thought to be reasonably accurate. It will be noted that although tractor numbers decrease during the period, horsepower is expected

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to increase because of the heavier tractors now being manufactured.

Table 14 makes use of the horsepower data developed in Table 13. In this table, diesel horsepower has been broken out of total horsepower. In the case of 1950 data, diesel horsepower is known to have accounted for 25% of the total horsepower of the Soviet tractor park. ^{14/} In the case of later years, diesel horsepower has been estimated to constitute the following percentages of total horsepower.

<u>Year</u>	<u>Diesel (%)</u>	<u>Non-Diesel (%)</u>
1951	30	70
1952	35	65
1953	42	58

These percentages are increased annually in view of the current trend to diesel tractor production, and in view of the attrition rate for pre-war tractors, which were largely non-diesel.

From these estimates it is possible to procure estimated diesel fuel consumption by Soviet agricultural diesel tractors. This has been done by calculating diesel consumption per horsepower. The factor devised makes use of the fact that in 1940 Soviet non-diesel (largely kerosene fueled) tractors consumed 0.536 metric tons of fuel per horsepower per year. ^{15/} Both US and USSR experience is that diesel tractors consume about 5/6 as much fuel per horsepower as kerosene tractors. ^{16/} Diesel consumption per horsepower can therefore be estimated at 0.445 tons per horsepower-year.

With the estimates presented in the previous discussed tables in mind, it is possible to discuss the consumption estimates presented in Table 11 in further detail.

Gasoline (including Ligroine) and Kerosene requirements represent estimates of the consumption of non-diesel agricultural tractors, to which has been added a small

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allowance for gasoline consumption by self-powered machine combines, threshing machines, and stationary engines. In estimating fuel consumption by non-diesel tractors, total non-diesel tractor horsepower was used in conjunction with the known pre-war consumption factor of 0.536 annual metric tons per horsepower. ^{17/} Since this factor was derived on the basis of data applying largely to non-diesel (kerosene) tractors, it is felt that this method of deriving total non-diesel fuel consumption is reasonable. However, the further break-down of this non-diesel fuel consumption into gasoline (including ligroine) and kerosene components is difficult. The break-down has been tentatively made on the estimated basis that in the pre-war period gasoline and ligroine represented 26.4% of the total non-diesel tractor fuel consumed. ^{18/} Since it is believed that kerosene fueled equipment may have accounted for slightly less of the total non-diesel fuel consumed in 1950, it has been assumed that gasoline and ligroine accounts for 30% of the total in 1950. Estimates made for gasoline and kerosene consumption by agricultural tractors are summarized as follows:

	Millions of Metric Tons				
	1950	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
Gasoline & ligroine	1.5	1.5	1.4	1.4	1.2
Kerosene	2.4	2.4	2.3	2.2	2.0
Total	4.9	4.9	4.7	4.6	4.2

Total non-diesel tractor fuel decreases progressively through peacetime 1953.

This takes into account the attrition rates of older, non-diesel equipment, and the increasing production of diesel tractors throughout the period. Gasoline (and ligroine) is again assumed to account for 30% of the non-diesel tractor fuel consumed in each year. In estimating gasoline and kerosene requirements in wartime fiscal 1953, the downward trend of gasoline, ligroine and kerosene consumption has been slightly

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accelerated. This gives recognition to the assumption that the importance of conserving liquid fuels would lead to a more selective use of tractors, with an attendant higher retirement rate for the older and less efficient non-diesel equipment.

To the above estimates of non-diesel tractor consumption has been added 0.1 million tons per year of gasoline for consumption by self-propelled combines, threshing machines, and stationary motors. 25X1 estimates place gasoline consumption by combines at 68,000 tons per year 19/. This figure has been used as a basis for estimating consumption of this type. It should be recognized, however, that little information is available on this subject, and that the 0.1 million ton consumption is included more in recognition of the existence of this type of demand than as an accurate appraisal of its magnitude.

Diesel fuel consumption by tractors in agriculture has been derived in Table 14. Wartime diesel tractor fuel requirements have been held at the 1952 level on the dual assumptions that maximum use would be made of the more efficient, newer diesel tractors in the event of war, and that no substantial quantity of new diesel tractors would be produced in wartime. No cognizance has been taken in preparing this wartime estimate of the possibility that a number of diesel tractors will be withdrawn from the farm tractor park and assigned to the military. This does not imply a reluctance to accept this possibility, but rather a recognition of the lack of data which would permit the estimate of the difference in diesel consumption resulting from such a transfer.

Diesel oil consumption has been increased by 0.1 million tons in each year to

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account for the fuel consumed by diesel tractors used in timber extraction. The best estimate available is that there are currently some 4,500 heavy diesel tractors in the lumber industry 20/ which might consume as much as this quantity of fuel.

Lubricating oil consumption estimates have been prepared on the basis of the fact that in 1940 a 10,260,000 horsepower tractor park consumed 0.4 million tons of lubricants 21/ or 0.039 tons per horsepower year. It was assumed that this rate of consumption would continue into the post-war period. In wartime 1953, the total of lubricants consumed was held at the 1950-52 level.

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3. Consumption of Petroleum Products by Shipping.Summary

The estimated total consumption in the Soviet Union of petroleum products for water transportation are set forth in Table 15. This consumption is composed of the consumptions of petroleum fuels and lubricants by three separate groups of Soviet merchant shipping. These are (a) the deep sea merchant fleet, by which is meant that major portion of the Soviet merchant marine which is employed in navigating waters from which access to the ocean is readily possible; (b) the fleet located in the landlocked Caspian sea; and (c) the river fleet which plies the rivers, canals, and other inland waterways of the USSR.

TABLE 15. Estimated Consumption of petroleum Products by Soviet Shipping

1950 - 1953

	Millions Metric Tons				
	1950	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
Diesel Oil	.5	.5	.6	.6	.6
Fuel Oil	1.2	1.2	1.2	1.2	1.1
Lubricants	.1	.1	.1	.1	.1
Total	1.8	1.8	1.9	1.9	1.8

Analysis of the consumption of petroleum products by each of these groups follows. In each case, it has been necessary to estimate total consumption from estimates of the composition, use, and unit consumption rates for the fleets concerned. Estimates based on this number of variables cannot help but be subject to error. This error is probably least in the case of the high seas fleet, since observations of its composition and fuel consumption rates are probably the most accurate. It is fortunate that this group of ships accounts for the major part of total petroleum requirements. Estimates

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concerning the river fleet are the most subject to question, since no reliable data are available on its composition. The over-all error introduced here is proportionately small, since it is thought that river shipping accounts for less than 20% of the total shipping requirement.

It will be noted that total peacetime consumption remains relatively constant.

This reflects the estimated stability in the composition and use of Soviet shipping.

However, the fact that the wartime requirements are indicated to be about the same as the last peacetime estimate should not conceal the differences in the composition of those requirements. The fuel requirement of the deep sea fleet is expected to decrease by 25% in the event of war; on the other hand, the fuel requirement of the Caspian fleet, operating in protected waters, is expected to increase. This is almost certain to be the case, especially in the event of the completion of the Volga-Don canal prior to the outbreak of hostilities. This would allow the transfer of the smaller units of the high seas fleet into the Caspian. It has not therefore been considered, as in the case of earlier studies, that the fuel requirements of the merchant fleet would decrease substantially in the event of war. The reliability of this assumption also depends, in large part, on the validity of the following hypotheses: (1) that no very substantial amount of Soviet shipping would be caught in Allied ports or on the high seas at the beginning of the war; (2) that the Soviets would succeed in trapping substantial amounts of foreign shipping in their own Black Sea and Arctic ports; (3) that Allied interdiction of Soviet shipping would not be possible in the Black Sea or Arctic, and would be possible only to a limited extent in the Baltic and Pacific, in the event of war.

a. Consumption of Petroleum Products by the Deep Sea Merchant Fleet.
Introduction.

The fuel consumption of the Russian deep sea merchant fleet shown in Table 16 is derived from analysis of the composition of that fleet, of the daily average fuel consumption of various petroleum fueled units in the fleet, and of the number of days which various units of the fleet spend at sea. Each of these data are subject to error.

A discussion of the methods used in determining each of these data follows:

TABLE 16 - Estimated Consumption of Petroleum Products by the
Deep Sea Merchant Fleet

1950 - 1953

	Million Metric Tons				
	1950	1951	1952	Fiscal 1953	Fiscal 1953
Diesel oil	.3	.3	.4	.4	.3
Fuel oil	.7	.7	.7	.7	.6
Lubricants	.1	.1	.1	.1	.1
Total	1.1	1.1	1.2	1.2	1.0

Analysis.

The estimated composition of the Soviet deep sea merchant fleet is presented in Table 17, Appendix. Particular attention has been paid to the composition of the petroleum fueled fleet, since this section of the fleet is of primary concern in this report. Table 17 has been compiled from data provided by the Office of Naval Intelligence.

Considerable confidence can be placed in the estimates of tonnage and types of vessels in the over-1000 gross rated tons (GRT) group, since a large part of this shipping was built in yards outside the Soviet Bloc. Any error may be expected to be in the direction of over-estimation, in view of the procedure used in compiling the roster of Soviet shipping. In this process, a merchantman known to be in Soviet hands is assumed to be operative until intelligence to the contrary is received. This error should not exceed plus 15%, since

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Less confidence can be placed in the estimates of shipping under 1000 GRT.

Much of this tonnage was built in the USSR, or in the Soviet Satellites. Less information is therefore available on these vessels. Even less confidence is placed in the estimates of the amount of this tonnage group which is diesel powered. The number of diesel vessels, and their tonnage, has been derived from a survey of 61 Russian ships

25X1 in this category From this survey, it was determined that 29.5% of these vessels were diesel powered. A 30% factor was therefore applied to ONI's estimates of total tonnage and numbers of vessels under 1000 GRT. In preparing Table 17 it is therefore felt that these figures may be subject to large, but undeterminable error.

In estimating the daily average fuel consumption of the petroleum consuming units of the fleet, use has been made of methods of estimation prepared by ONI. Three separate methods were developed. These concern: (1) "Liberty" type vessels; (2) other types of oil-fueled steam vessels; (3) diesel vessels.

(1) "Liberty" Type Vessels. Fuel consumption of this type of ship is known to be about 190 barrels of fuel oil per day ^{22/}. This equals 29.12 metric tons per day. This factor, based on U.S. experience, should be extremely accurate.

(2) Other Types of Oil-fueled Steam Vessels. A study of 40 older ex-US ships still "on loan" to Russia shows that these vessels total 216,611 gross tons, and 100,300 shaft horsepower. ^{23/} This permits derivation of a factor of .463 shaft horsepower per gross ton. Another study of 50 US ships of this type built before 1941 indicates that this factor should be .475 shaft horsepower per gross ton. ^{24/} A compromise factor of .47 was therefore used.

A further study of 20 older ex-US ships in Russian hands indicates that they aggregate 49,250 shaft horsepower, and consume 682 long tons of fuel per day at sea. This

means that consumption is .0138 long tons of fuel per shaft horsepower per day. This factor is in close accord with another US source, 25/ which states that oil burning merchantmen consumer 1.25 pounds of fuel oil per shaft horsepower per hour, or .0134 long tons per day.

A compound factor can therefore be derived relating gross tonnage to fuel consumption in long tons per day. This is :

$$(.47) \times (.0138) = .00649$$

Or, converting from long tons to metric tons, .00659 metric tons of fuel oil per gross ton per day at sea. It is felt that this factor will be reasonably accurate when used in calculating fuel oil consumption for a relatively large number of ships. Sample calculations for ships known to be in Russian hands indicate that an error of 5% may be anticipated as a general rule.

(3) Diesel Vessels. A study of 184 US flag diesel merchantmen over 1000 GRT yielded a total of 835,369 gross tons, and 521,275 brake horsepower. 26/ This gives a factor of .625 horsepower per gross ton. It is stated in a reliable US source 27/ that diesel fuel consumption for diesel merchantmen should be about .4 pounds per brake horsepower hour, or .00437 metric tons per brake horsepower per day. This permits derivation of a compound factor of .00273 metric tons of diesel fuel per gross ton per day at sea. This factor has also been tested against known performance records of 19 Russian diesel merchantmen, and has been found to result in errors of less than 5%.

In estimating the number of days spent at sea by the various components of the merchant fleet, ONI assumed that a freighter spends 160 days per year at sea, and the balance in port. This figure was derived by reducing by 20% the number of days at sea which the U. S. has experienced with freighters similar to those of the USSR. This

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allows for slower loading and discharging rates, and for poorer conditions of vessel maintenance, in the USSR. A similar method was used in determining that tankers would spend 215 days at sea, and 150 in port. In the case of vessels under 1000 GRT, it has been arbitrarily assumed that they would spend about 50% of their time at sea. In conjunction with the use of these factors, it has been assumed throughout that a vessel will burn about 20% as much fuel in port as at sea.

It has not been possible to estimate the degree of error which may be introduced in this factor. It is probably the factor most subject to error used in the calculations of consumption.

After this discussion of methodology, it is possible to comment on the petroleum product consumption estimates outlined in Table 16.

Diesel fuel consumption in 1951 is calculated from the factors discussed above as follows:

	<u>Days</u>	<u>GRT</u>	<u>Fuel Factor</u>	<u>In Port Factor</u>	<u>Product Metric tons per year</u>
<u>Vessels over 1000 GRT</u>					
<u>Tankers</u>					
At Sea	215	101,013	.00273	-	59,300
In Port	150	101,013	.00273	.2	8,300
Total					67,600
<u>All others</u>					
At Sea	160	320,647	.00273	-	140,100
In Port	205	320,647	.00273	.2	35,900
Total					176,000
<u>Vessels under 1000 GRT</u>					
At Sea	180	59,400	.00273	-	29,200
In Port	185	59,400	.00273	.2	6,000
Total					35,200
<u>Grand Total</u>					278,800

A rounded figure of .3 million metric tons has therefore been used as the estimate of diesel fuel consumption for 1951. In projecting the trend of diesel fuel consumption in peacetime, allowance has been made for the reported construction in the Soviet satellites of a considerable, but unknown, amount of small vessel diesel tonnage for Soviet account. Diesel consumption is therefore expected to increase gradually through peacetime 1953. In the event of war, it is anticipated that Soviet shipping activity on the high seas would be considerably curtailed. At the same time, the volume of coastal shipping, and shipping in protected areas, might increase, notably for smaller craft. Diesel requirements might therefore fall below their present levels, but would not be substantially reduced. An arbitrary 25% cut below the estimated 1953 levels has therefore been indicated.

Fuel oil consumption is derived as follows:

<u>Vessels over 1000 GRT</u>	<u>Days</u>	<u>No. of Vessels</u>	<u>Fuel Factor</u>	<u>In Port Factor</u>	<u>Product Metric tons per year</u>
<u>"Liberty" type vessels</u>					
At Sea	160	38	29.12	-	177,000
In Port	205	38	29.12	.2	45,400
Total					222,400
<u>Other vessels over 1000 GRT</u>					
<u>Tankers</u>	<u>Days</u>	<u>GRT</u>	<u>Fuel Factor</u>	<u>In Port Factor</u>	<u>Product Metric Tons per year</u>
At Sea	215	21,175	.00659	-	30,000
In Port	150	21,175	.00659	.2	4,200
Total					34,200
<u>All others</u>					
At Sea	160	363,244	.00659	-	383,000
In Port	205	363,244	.00659	.2	98,100
Total					481,100
<u>Grand Total</u>					737,700

Fuel oil consumption in 1951 has been estimated to be .7 million metric tons.

The rate of increase in fuel oil consumption through peacetime 1953 is thought to be so small as to be insignificant. The most fuel oil is consumed by the larger cargo ships in the fleet, and it is believed that there will be very few additions to the fleet in the larger tonnage categories. In wartime, it is again anticipated that there will be a reduction in fuel oil requirements, as the fleet is withdrawn from the high seas. While some of this shipping might be diverted to the coastal trade, or to protected seas, a 25% reduction in fuel oil requirements does not seem far fetched.

Lubricating oil consumption estimates should take into account the lubrication needs of the whole merchant fleet-oil fueled, coal fueled, and diesel fueled. It was therefore estimated somewhat arbitrarily that each ship over 1000 GRT would use an average of 1 barrel of lubricants per day, while each ship under 1000 GRT would use only half that amount per day. This would result in a consumption of some 275,000 barrels of lubricants per year, or less than .05 million metric tons. For the sake of completeness, it has been necessary to record 0.1 million tons of lubricants consumption in Table 16. This is because estimated total lubricant consumption by all types of Soviet shipping approaches this figure; the greatest part of total lubricating oil consumption by all shipping occurs in this group.

b. Consumption of Petroleum Products by the Caspian Merchant Fleet.

Introduction.

The consumption of petroleum products by the Caspian merchant fleet, as shown in Table 18, is estimated on the basis of data concerning the composition of the Caspian

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fleet, its daily fuel requirements, and the number of days which units of the fleet spend at sea. This method is the same as that used in preparing estimates of the consumption of petroleum products by the deep sea merchant fleet.

TABLE 18. Estimated Consumption of Petroleum Products by
the Soviet Caspian Sea Merchant Fleet
1950 - 1953

	Millions Metric Tons				
	1950	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
Diesel oil	.1	.1	.1	.1	.2
Fuel oil	.3	.3	.3	.3	.4
Lubricants	<u>.2</u>	<u>.2</u>	<u>.2</u>	<u>.2</u>	<u>.2</u>
	.4	.4	.4	.4	.6

a/ Negligible.

Table 19, Appendix, has been prepared from ONI data. 28/ As indicated in the table, only incomplete information is available on 34 vessels, totaling 124,500 gross rated ton (GRT). Of these vessels, 19 totaling 92,500 GRT were known to be under construction in 1942; no factual information is available on the types of engines with which these vessels are equipped. For this report, it has been assumed that these vessels were equipped with oil-steam engines, in view of the tendency for the Soviet to equip its most modern large vessels with this type of engine. It has been assumed, in addition, that the remaining 15 vessels of the 34 cited above, known to total about 32,000 GRT, are also oil-steam engined.

Information on the number of vessels under 1000 GRT plying the Caspian is currently entirely lacking. Purely as a means of estimating the general magnitude of the petroleum requirements of these vessels, it has been assumed that there is in existence in the Caspian the same proportion of tonnage under 1000 GRT as in the case of the deep sea fleet. It has further been assumed, since it is felt that this

is probably a very conservative estimate, that most of these vessels will be diesel fueled.

This assumption seems tenable in view of the relatively high degree of availability of petroleum fuels in this area.

It must further be observed that the completeness and accuracy of Table 19 is subject to question, since few reliable current observations are available from which it would be possible to bring these estimates of strength and composition of the Caspian fleet up to date.

The daily fuel requirements of the various types of vessels which make up the Caspian fleet have been estimated on the same basis as the daily fuel requirements for the deep sea fleet. Some error is probably introduced by using the assumption that the Caspian fleet consumes fuel at the same rate as equivalent vessels in the deep sea fleet. The Caspian fleet contains a greater number of smaller vessels, so that it appears to average just over 2,000 GRT per vessel; the deep sea petroleum fueled fleet averages about 3,150 GRT per vessel. The degree of error which is thus introduced cannot be estimated.

Some further error is probably also introduced by assuming that vessels in the Caspian fleet spend the same number of days at sea as those in the deep sea fleet. The facts that the average voyage is probably shorter in the Caspian and that the Northern Caspian is ice-blocked in winter would indicate that this might be the case. However, it must also be pointed out that a large portion of the Soviet deep sea fleet is engaged in a coastwise trade in seasonally ice-blocked waters. It therefore seems not too unreasonable to assume that the number of days at sea is approximately the same. Further information is needed on this subject before firmer assumptions can be made.

In the light of these assumptions, the following commentary on the consumption estimates indicated in Table 18 is possible.

Diesel fuel consumption of the Soviet Caspian Sea merchant fleet is estimated as follows:

	<u>Days</u>	<u>GRT</u>	<u>Fuel Factor</u>	<u>In port factor</u>	<u>Total consumption (Metric tons per year)</u>
<u>Vessels over 1000 GRT</u>					
Tankers					
At Sea	215	104,600	.00273	-	61,400
In Port	150	104,600	.00273	.2	8,600
Total					<u>70,000</u>
All others					
At Sea	160	16,400	.00273	-	7,300
In Port	205	16,400	.00273	.2	1,800
Total					<u>9,100</u>
<u>Vessels under 1000 GRT</u>					
At Sea	180	32,000	.00273	-	15,700
In port	185	32,000	.00273	.2	3,300
Total					<u>19,000</u>
<u>GRAND TOTAL</u>					<u>98,100</u>

Diesel fuel consumption is estimated to be about .1 million metric tons. This is a little higher than in previous estimates; the difference lies primarily in the inclusion in the current estimate of diesel fuel for consumption by units under 1000 GRT. The estimate of .1 million tons has been continued throughout the peacetime period under review. Actually, there will probably be some increase in diesel fuel consumption in this area, particularly in the tonnage category under 1000 GRT; however, it is not felt that this increase will be substantial. In the event of war, shipping activity in these protected waters might be expected to increase, together with the general level of economic activity. A small increase has therefore been recorded. The figure

of 2 million tons may be regarded as the optimum diesel consumption that can be anticipated in wartime, on the basis of present knowledge.

Fuel oil consumption of the Soviet Caspian Sea merchant fleet is estimated in accordance with the calculation presented below:

	<u>Days</u>	<u>GRT</u>	<u>Fuel Factor</u>	<u>In port Factor</u>	<u>Total Consumption (Metric tons per year)</u>
<u>Vessels over 1000 GRT</u>					
Tankers					
At Sea	215	172,000	.00659	-	243,700
In Port	150	172,000	.00659	.2	34,000
Total					<u>277,700</u>
All others					
At Sea	160	27,900	.00659	-	29,400
In port	205	27,900	.00659	.2	7,500
Total					<u>36,900</u>
<u>Grand Total</u>					<u>314,600</u>

This calculation results in an estimated consumption of about .3 million tons of fuel oil. This estimate is some 40% lower than previous estimates. It can only be presumed that different assumptions have been made, although it has not been possible to identify the assumptions made in the earlier estimates. There is no existing evidence which indicates that fuel oil consumption by the Caspian fleet is increasing at any considerable rate. Consumption has therefore been held constant in the period. Wartime estimates have been very slightly increased to allow for the increased wartime activity mentioned above.

Lubricating oil consumption has been estimated in the same manner as the consumption of lubricants by the deep sea merchant fleet. It should approximate 51,000 barrels per year, or less than 10,000 metric tons. This requirement is too small to be taken into account in this study.

c. Consumption of Petroleum Products by the River Fleet.

Introduction.

The consumption estimates presented in Table 20 depend on the accuracy of calculations regarding the composition of the Soviet river fleet, its horsepower, and its consumption per horsepower.

TABLE 20. Estimated Consumption of Petroleum Products
by the Soviet River Fleet
1950 - 1953

	Million Metric Tons				
	1950	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
Diesel Oil	.1	.1	.1	.1	.1
Fuel Oil	.2	.2	.2	.2	.2
Lubricants	.3	.3	.3	.3	.3

a/ Negligible.

The pre-World War II inventory of the Soviet river fleet is estimated to have included 3,600 self propelled units of 810,000 horsepower, as well as some 11,500 non-self-propelled units. ^{29/} This means that 24% of the pre-war fleet was self propelled. During the war, some 4,000 river units of all types were claimed to have been destroyed. ^{30/} Assuming that 24% of these were self-propelled, the post war inventory of self-propelled vessels would have totaled about 2,640 units. The pre-war horsepower per self propelled unit can be calculated to average 225 horsepower from the above data. Assuming that the postwar inventory would average this figure, it could be expected to have totaled 594,000 horsepower after the war. The Five Year Plan which ended in 1950 had as one of its objectives increasing the river fleet by 300,000 horsepower. ^{31/} It is not known whether this objective was attained. It is known, however, that the Five Year Plan for the river fleet was only 91% fulfilled, in terms of the increase in total cargo carried. ^{32/} Utilization of equipment appears to have been about the same as that planned. It seems possible to assume, then, that only 90% of the net horsepower increase planned

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was achieved. This would mean that the horsepower inventory of the fleet would have stood at about 864,000 by the end of 1950. If it is then assumed that the net annual gain in horsepower that could be expected after 1950 would not be greater than the 60,000 horsepower average per year planned between 1945 and 1950, the inventory of the fleet would increase gradually to 1,014,000 horsepower by mid-1953. This would mean that the mid-period inventories for the years 1951, 1952, and fiscal 1953 would be about 894,000, 954,000 and 984,000 horsepower, respectively.

No positive information on the percentage of the total inventory which is coal burning is available. been used which estimates that the fleet is 75% petroleum fueled. ^{33/} The division of this oil burning inventory into oil-steam and diesel presents a further problem; an earlier estimate is that 2/3 of the petroleum fueled vessels are oil-steam. ^{34/} Recent estimates also indicate that 90% of the inventory is serviceable. The estimated serviceable mid-year inventory of the horsepower of the Soviet River Fleet is therefore estimated to be the following:

	<u>Thousand Horsepower</u>			
	1951	<u>Peace</u> 1952	Fiscal 1953	<u>War</u> Fiscal 1953
Total inventory	894	954	984	984
Less: 10% unserviceable	<u>89</u>	<u>95</u>	<u>98</u>	<u>98</u>
Total serviceable inventory	805	859	886	886
Diesel powered	201	214	221	221
Oil-steam powered	403	430	443	443
Coal-steam powered	<u>201</u>	<u>215</u>	<u>222</u>	<u>222</u>
Total	805	859	886	886

It will here be assumed that river vessels are used about 1790 hours per year.

This assumption is derived from two facts: that 200 days of annual operation is typical for Soviet river craft, ^{35/} and that river craft are in motion about 37.2% of the time.

^{36/} In wartime, it is assumed that it would be possible to increase this utilization of vessels by an arbitrary 10%, resulting in 1970 hours of operation per year. It has been

assumed, as in an study, ^{37/} that diesel river boats consume .000312

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metric tons of diesel fuel per horsepower hour, and that oil-steam vessels consume .000223 metric tons of fuel oil per horsepower hour.

Lubricant consumption has been assumed to be about 5% of the diesel and fuel oil requirement for petroleum fueled vessels. Since petroleum fueled vessels constitute 75% of the self-propelled fleet, it follows that some adjustment must be made to provide for the lubricants consumed by the coal fueled fleet. This adjustment factor has been considered to be $\frac{100}{75}$, or 1.33 times the lubricants consumption of the petroleum fueled fleet.

From these assumptions, it is possible to derive Table 21, Appendix A.

It will be seen that the diesel oil consumption set forth in Table 20 for the inland fleet has been estimated throughout the period at .1 million metric tons per year, despite the slightly increasing consumption shown in the Appendix, Table 21. Similarly, the fuel oil consumption estimate does not exceed .2 million metric tons during the period. Lubricant consumption is too small to be recorded in Table 20.

It should again be pointed out that these consumption estimates cannot be very accurate, and may only be considered to be order-of-magnitude estimates. This is due to the many assumed variables which have been incorporated in the method of calculation. This methodology has been used in a previous report, and has been improved on only in minor respects. Studies currently in progress promise to produce firmer estimates.

In the interim, the data presented in Table 20 can be regarded as adequate, since the total demand for river transportation appears to be small, and since fairly large errors in the factors used in calculation would result only in small changes in the total consumption of products.

4. Consumption of Petroleum Products by the Railroads.

Estimated consumption of petroleum products by the railroads of the USSR are summarized in Table 22. Conflicting and inadequate data make estimates in this area of consumption difficult. However, it appears that fuel oil consumption by the railroads may be somewhat less than has previously been estimated. Since no evidence is available currently which would foreshadow any substantial change in railroad petroleum product demand, consumption has been held constant throughout the peacetime period. In war, it is believed that the USSR would continue to operate its oil fueled rail net at approximately peacetime levels, and hence the wartime requirements show no change.

TABLE 22. Estimated Consumption of Petroleum Products
by Railroads in the USSR
1950 - 1953

	Million Metric Tons				
	1950	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
Kerosene	0	0	0	0	0
Diesel Oil	.1	.1	.1	.1	.1
Fuel oil	1.8	1.8	1.8	1.8	1.8
Lubricants	.1	.1	.1	.1	.1
Total	2.0	2.0	2.0	2.0	2.0

Kerosene is used by the Soviet railroads for lighting and heating and as a solvent. Russian statistics classify railroad use of kerosene as "industrial" use of this product. In order to avoid duplication, kerosene consumption by the railroads is included in part 5 of this report in the estimate of industrial use of this product. In any case it is not considered that railroad consumption of kerosene could be very great. It may be so small as to be negligible.

Diesel fuel consumption has been based on an estimated 1950 total of 166 diesel locomotives 38/ in operation on USSR railroads. Fuel consumption per diesel locomotive

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has been estimated at 600 tons per year, in view of the experience with diesel engines in the US during 1947 39/. Combining these figures, a total consumption of just under 100,000 tons of diesel fuel during 1950 is obtained. Since post-1950 production of diesel locomotives in the USSR is probably falling short of the small number planned 40/, diesel fuel consumption has not been increased during the peacetime period under review. Wartime diesel fuel requirements have been estimated to be approximately the same as in peacetime, since it can be anticipated that existing diesel traction will continue to be used to capacity in an emergency, while production of new diesel equipment may be slackened or discontinued.

In estimating the fuel oil consumption of the railroads, several methods have been used. Since available data on fuel oil consumption by the railroads is scant, it has been necessary to follow a somewhat tortuous course of analysis in each case.

Method I. From a recently published article in the Soviet press, 41/ it can be determined that 221 kilograms of fuel were consumed by the railroads in the USSR during 1950 per 10,000 ton-kilometers of gross train weight. While not specifically stated in the source, it is believed that this figure of 221 kilograms refers to standard fuel. It is calculated that Russian railroads carried 601 billion net ton kilometers of traffic during 1950 42/. The relationship between net and gross train weight in the USSR is approximately the same as in the US, or 1 to 1.2. 43/ Therefore, a total of 1,276 billion gross ton kilometers of traffic can be calculated for 1950. This would result in an estimated 28.2 million metric tons of standard fuel consumption by the railroads in 1950.

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Since no evidence is currently available on the absolute amounts of fuel oil consumed by steam locomotives, it is necessary in this method to make use of the statistics which the USSR has made available in the past on the percentile relationships between the various rail fuels, most probably expressed in standard fuel equivalents:

The 1950 estimate presented in Table 23 allocates to coal of all types the same percentage of total fuel consumption as was the case in 1946. Hard coal is thought to account for a greater percentage of total coal consumption than in 1946 in view of the complete reopening of the Donetz coal mines since that date. Consumption of wood, which accounted for only a very small part of the 1946 total, is thought to have become insignificant. Estimated petroleum consumption is therefore placed at 3% of the total fuel consumption, in terms of standard fuel.

TABLE 23. Percentage Composition
of Railroad Fuel, USSR
1940 - 1950

	^{a/} 1940	^{a/} 1943	^{a/} 1946	1950 (Est.)
Coal	84.6	64.5	75.4	80
Lignite	6.3	17.2	21.6	17
Wood	1.0	11.5	0.3	-
Oil	8.0	6.8	2.6	3
	100.0	100.0	100.0	100

^{a/} Refer to reference 44/, 45/ and 46/ for 1940, 1943 and 1946 respectively.

If the 1950 estimate is accepted, it will be apparent that petroleum can be estimated to have accounted for 3% of the 28.2 million tons of standard fuel calculated above, or .85 million metric tons of standard fuel. The factor used by the Soviet in 1932-33 to convert fuel oil to standard fuel was approximately 1:1. ^{41/} This would

mean that fuel oil consumption by the railroads in the USSR in 1950 would be about .9 million tons.

Method II. This method is similar to that used in earlier reports. It is known that in 1940 the Soviet railroads consumed 93.5% of total coal consumed by all forms of transportation, and that this total was 49 million tons. ^{43/} The railroads therefore consumed 45.8 million tons of coal of all types. Since it is estimated that coal represented 90.9% of coal fuel consumed by the railroads, ^{42/} and that oil accounted for 8.1% of the same total, it follows that oil accounted for 4.08 million tons of coal expressed in coal units. The ratio used by Soviet statisticians in preparing 1932-33 data ^{50/} for relating fuel oil and coal consumed by the railroads (in terms of standard fuel) has been calculated to be 1.8:1. In view of the poorer overall quality of 1940 coal production, as compared to 1932-33, a conversion ratio of 2:1 does not seem unreasonable when dealing with 1940 data. This conversion factor can also be independently arrived at from another Russian source. ^{51/} In this source, the relative 1936 heating values of fuel oil, coal and lignite when burned under locomotives boilers, are given as .98 ($\frac{1}{2}$), .55 ($\frac{1}{2}$) and .35 ($\frac{1}{2}$), respectively, in terms of standard fuel. This would mean a relationship between fuel oil and an 80-17 coal-lignite blend (see table above) of about 2:1. Using this factor, 1940 fuel oil consumption by the railroads can be estimated to be about 2.0 million metric tons. Earlier studies assume that 1950 fuel oil requirements for the railroads were approximately the same as those in 1940. This assumption seems possible in view of the facts that: (a) although overall traffic may have increased, it seems probable that most of the increase has occurred in the area of coal traction; (b) increased

diesel traction since 1940 is known to have replaced less efficient fuel oil traction at least to some extent. 1950 fuel oil requirements for the railroads are, therefore, estimated at 2.0 million metric tons by this method.

Method III is based on the assumption that there exists a relationship between total track kilometrage devoted to oil traction, and the amount of fuel oil consumed in rail transport. The Soviet Plan for 1950 called for 6% of a total of 118,000 kilometers of trackage to be served by oil traction. ^{52/} It is then arbitrarily assumed, in view of the location of the oil fueled railroads in the Caucasus and Central Asia, that these roads would bear slightly less than their proportionate share of traffic. It has, therefore, been estimated that these roads would bear roughly 5% of the total ton kilometrage of USSR rail traffic. Applying this factor to the fuel consumption of 28.2 million tons of standard fuel (which is derived from gross ton kilometrage) in method I, it would appear that about 1.4 million tons of standard fuel could be consumed on the oil fueled roads. Using the conversion factor of 1 : 1, this would mean that 1.4 million metric tons of fuel oil were consumed by the Soviet railroads in 1950. It is recognized that this method is subject to wide error; however, it is believed that a range between 4 and 6% might represent the maximum and minimum reasonable estimates for the proportion of total ton kilometrage carried by oil fueled railroads. These factors would result in a range of estimate for total fuel consumption between 1.1 and 1.7 million metric tons in 1950.

In view of the results of these methods of estimation, it would appear that current fuel oil consumption by the USSR railroads may have been somewhat overestimated in the past. A range of between .9 and 2.0 million metric tons has been derived in the above calculations. Since slightly more confidence is placed in Method II than in the

other methods, the estimate of the most probable fuel oil consumption has been placed at 1.8 million metric tons (Error - 50%, \pm 10%).

No data are currently available which would indicate that fuel oil consumption by the railroads in peacetime will vary substantially. In view of this fact, the estimates for 1950 have been carried forward throughout the period. It is believed that the fuel oil requirements of the railroads during war would not be substantially different from those in peacetime. While it might be assumed that some wartime conversion from oil to other fuels would be possible, the experience of the last war indicates that this would not be the case. On the other hand, the obvious wartime requirement that the rail net operate at maximum efficiency would tend to indicate that no reduction in fuel oil requirements could be anticipated.

Intelligence on the amount of lubricants consumed by the Soviet railroads is currently lacking. Earlier estimates, based on incomplete Soviet data, have placed lubricating oil consumption by the Russian railroads at approximately .1 million metric tons per year. In an effort to check this estimate, use has been made of data on lubricant consumption by locomotives in Austria. 53/ Relating Austrian consumption of lubricants per locomotive kilometer to the estimated kilometrage run by Russian locomotives in the period under review, it is possible to obtain an estimate of 22,100 metric tons per year of lubricants consumed by locomotives in the USSR. This figure excludes lubricant consumption by rolling stock and passenger locomotives.

In another approach to the problem, the lubricant consumption in 1939 of the Great Northern Railroad in the United States was calculated to be 52.2 kilograms

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per million gross ton kilometers 54. This figure includes all grease and lubricants used in operating, repairing, and maintaining the locomotives and rolling stock of this railroad. Both in terms of the climatic conditions under which this railroad operates, and in terms of the diesel-steam ratios present in its locomotive inventory in 1939, this railroad is the closest US analogy to the Soviet railroad system. It is therefore felt that the above lube consumption may serve as a valid check on other methods of estimate. Using this factor of 52.2 kilograms of lubricants, an estimated consumption of 66,600 metric tons per year of lubricants may be obtained.

It is therefore considered that railroad consumption of lubricants in the USSR will be somewhat less than .1 million tons per year during the peacetime period under review. Since there is no evidence which would lead to a substantial revision of this figure in wartime, the same estimate has also been used for wartime fiscal 1953.

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5. Consumption of Petroleum Products by Industry.

Summary.

This section is concerned with the consumption of petroleum products by industry in the USSR, including requirements for power generation. However, consumption of kerosene by industry is considered in the section dealing with home consumption. There are very limited data available on the consumption of gasoline, diesel oil, fuel oil, and lubricants by Soviet industry. This report reflects the present unsatisfactory state of our knowledge in this field and indicates that the requirements presented in Table 24 must be regarded as tentative and subject to important revisions when better data are available.

TABLE 24. Estimated Consumption of Petroleum Products
by Industry in the USSR
1950 - 1953

	Million Metric Tons				
	1950	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
Gasoline	.5	.5	.6	.6	.5
Diesel oil	1.2	1.3	1.5	1.5	1.2
Fuel oil	8.4	9.5	10.2	10.7	8.2
Lubricants	1.2	1.3	1.5	1.2	1.2
Total	11.3	12.3	13.8	14.3	11.1

Very few positive conclusions may be drawn from the analysis of industrial requirements, since so very little is known about these requirements. This is particularly true in the area of industrial gasoline, diesel oil, and lubricating oil requirements. The current lack of intelligence on requirements for these products is particularly serious, since the most difficulty will be encountered in finding substitutes for these products. It is not possible to consider in the case of these

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products, as in the case of industrial fuel oil, that the industrial demand is the marginal demand which may be undersupplied in the event of necessity. There must clearly be a minimum demand for these products without which Soviet industry will not function effectively. The present state of our knowledge does not permit us to determine this minimum. A much more extensive analysis than has been possible at this writing would be required to obtain accurate estimates.

In the case of the industrial requirement for fuel oil, a somewhat more satisfactory state of affairs exists. If it is assumed that industrial demand is marginal to other demands for fuel oil, - an assumption made possible by the relatively high degree of convertability present in industrial fuel oil burning equipment - it is possible to approximate industrial fuel oil consumption. It would appear that supplies of fuel oil are currently adequate, and would continue to be so, even in the event of war.

a. Consumption of Gasoline.

The most recent firm datum available on this subject is the statement in a Soviet source that gasoline consumption by industry amounted to 190,000 metric tons in 1936 55/. The latest estimates make use of this known fact, and, by projecting this figure in accordance with industrial growth and the trend in overall consumption of petroleum products, arrive at the estimates indicated in Table 24. Two facts may be presented in defense of these estimates: (1) it is probable that the industrial consumption of gasoline is relatively small; (2) it is probable that the present consumption of gasoline by industry is at least as big as in 1936, and it is not unreasonable to suppose that it is twice as large in post-war years. However, these estimates cannot be regarded

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as anything more than directionally correct. They may be subject to an error of $\pm 40\%$, $\pm 50\%$, or more.

b. Consumption of Diesel Oil.

No firm data are available from which this requirement may be estimated. It is known that the 1936 consumption of heavy diesel fuel by agriculture and industrial-technical groups totaled 1.5 million tons. ^{56/} Unfortunately, no further breakdown of this information is given. Recourse was therefore had to an earlier estimate ^{57/} to a study of the German economy, which showed that about 35% of the diesel fuel produced went to industry. From this base it was estimated that in 1937 Russian industrial consumption of diesel must have been about 800,000 metric tons, increasing to 900,000 tons by 1940. The most recent estimates have been made by taking into account industrial growth and the increase in overall petroleum product consumption and applying these increases to the earlier estimate. This method is unsatisfactory, since it is known that Germany was far ahead of the USSR in the design, manufacture, and use of diesel equipment. The methodology is particularly insufficient because of the relatively large quantity of diesel fuel estimated to be involved. The present state of our knowledge does not permit improvement without an intensive analysis which has not been possible in this report. These estimated requirements are therefore subject to possibilities of great error.

c. Consumption of Fuel Oil.

The largest industrial petroleum product requirement in the USSR, as in any other industrialized economy, is for fuel oil. Very little direct evidence is available on the consumption of fuel oil by industry. However, the high degree of convertibility

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of most fuel oil consuming equipment in industry permits a method of estimation here which would not be practicable for other types of petroleum fuels.

It may be assumed that in the USSR the fuel oil requirements of the armed forces, the railroads, and merchant shipping - with their characteristically lower degree of convertability to other fuels - will be met first out of Soviet fuel oil supplies. The remaining supplies of fuel oil may then be assumed to be allocated to industry. This method, which equates industrial demand with the marginal availability of fuel oil, does have the disadvantage of making impossible an estimate of the amount of any fuel oil which may be going into stocks. It has the advantage, however, of indicating the maximum amount of fuel oil which is available to industry.

Table 25, Appendix, derives the industrial consumption of fuel oil in the USSR during the period 1950-1953 by the method outlined above. The crude production at the well-head shown in this table is that presented in I-A, Availability of Crude Petroleum in the USSR. Crude production during fiscal 1953 is considered to be the same under the assumptions of both peace and war, in view of the discussion of wartime potentials presented in that paper. Refinery runs to stills have been calculated on the basis of 95% of crude production at the well-head. Minimum production of fuel oil from refinery runs in the USSR is estimated to be 29.9% by weight of the Russian crude run, in view of the data shown in I-C, Refining of Petroleum in the USSR. Production of fuel oil from imported Rumanian mazut (topped crude) has been estimated to be 50% of annual imports of 1 million metric tons.

Fuel oil available from Estonian shale production has been estimated to be about 0.5 million metric tons per year. The sum of the above items, less the 1% product

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loss discussed in IV-A, Petroleum Products in the Soviet Bloc, gives the total fuel oil available to the USSR in the years in question.

Fuel oil requirements of the Soviet Armed Forces have been taken from estimates prepared by the relevant military intelligence groups for other papers. Ground and Air Force requirements for fuel oil are thought to be negligible. Peacetime naval requirements have been derived from an estimate of fuel oil requirements for peacetime fiscal 1953. 60/ Wartime naval requirements for fuel oil are the same as those shown in an earlier paper. 61/ Railroad and shipping requirements are those presented in relevant sections of this report. These figures are discussed in detail in the sections of this report dealing with those requirements.

The results of these calculations show that the fuel oil available to industry increases from 8.0 million metric tons in 1950 to 10.2 million metric tons in peacetime fiscal 1953. In wartime, the availability of fuel oil to industry decreases to 8.2 million metric tons.

In addition, it is necessary to take into account in this calculation the crude oil consumed in the producing field by the oil industry. This crude, which is burned as fuel, is estimated to amount to about 1% of the crude produced at the well head in IV-A, Petroleum Products in the Soviet Bloc. By taking this amount of crude burned as fuel into account, the industrial consumption of fuel oil (including crude burned as fuel) is increased somewhat.

It has been possible at this writing to partially identify the industrial consumers of fuel oil. This allows a very rough check of the industrial consumption of fuel oil, since the method used in this calculation is different. The method

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used to identify the various consumers has been that of analysing the input requirements of fuel oil for various Soviet industries. Since this has been done partly by analogy with US industry, there exists a strong possibility of error. However, such 1951 inputs of fuel oil as have currently been made by specialists in the various industries presented below are presented below, and compared with the calculated 1951 availability of industrial fuel oil.

Industry	1951 Fuel Oil Inputs (Million Metric Tons per Year)
Ferrous Metals	3.5
Petroleum Production (Crude)	.4
Petroleum Refining	1.2
Electric Power	1.5
Machinery	.2
Shipbuilding	.2
Rail Equipment	.1
	<u>6.7</u>
Availability, 1951:	9.5
Unaccounted for:	2.6

In connection with the above, it must be pointed out that a fuel oil requirement for the petroleum refining industry has been included, since the factor used in deriving fuel oil production in Russian refineries is that for deriving total fuel oil produced by refineries, before deducting refinery use of fuel oil. Refinery use of fuel oil has been calculated to be about 3% by weight of the crude oil run, or about 1.2 million tons of fuel oil. Other industrial requirements have been derived by input analysis, as outlined above. The fact that in 1951 some 2.6 million tons have not been accounted for does not suggest that this amount went to stocks. Our knowledge is currently insufficient to determine the disposition of this increment of fuel oil. It is obvious, however, that some of this oil could have gone to at least the following uses, aside from a build-up of stocks: (1) exports of fuel oil from the USSR; (2) input requirements for industries which were not surveyed; (3) product losses. In addition, there is also the possibility that the estimates from which the surplus of fuel oil were derived are in error.

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Some further comments are possible on the subject of the availability of fuel oil to industry in the event of war. It is probable that this availability will vary more directly with the total crude production of the USSR than with any other factor. It is not considered probable that the amounts of Rumanian mazut imported will be increased, or that fuel oil produced from shale will be available in any greater quantities than have been indicated. If crude production continues at estimated levels, and in the absence of damage to the refining or distributing facilities of the USSR, it appears that the availability of fuel oil to industry in war will be the same as that in peacetime, less whatever the increase in naval requirements will be. It does not appear that even a very large increase in naval requirements will produce any acute shortage of fuel oil, especially when possibilities of industrial conversion to coal are taken into account. The figures presented in Table 24 seem to bear this out.

d. Consumption of Lubricants.

No concrete data are available on which to base lubricating oil consumption estimates. The original estimate ^{92/} appears to have been made on the basic assumption that Russian industry would consume a little more lubricating oil than German industry. German consumption was estimated to be about .5 million tons per "normal" year, and Russian consumption was therefore estimated to be about .6 million tons in 1937, increasing to .8 million tons by 1940. These figures were extended in the most recent estimates to the levels indicated in Table 24. These estimates are therefore subject to great possible error, and so little is currently known about this subject that it is not feasible to fix the degree of possible error at the moment.

6. Consumption of Petroleum Products by Homes.

Table 26 presents estimated kerosene consumption by industrial and home consumers in the period 1950 - 1953. Industrial and home consumption of kerosene are treated together since it has been impossible to separate the two in known Soviet sources.

TABLE 26. Estimated Home and Industrial Consumption of
Petroleum Products in the USSR
1950 - 1953

	Million Metric Tons				
	1950	1951	1952	Fiscal 1953	May Fiscal 1953
Kerosene	1.9	1.9	1.9	1.9	1.0

Consumption of kerosene has been tentatively estimated to be about the same in 1950-53 as the planned production of kerosene for home and industrial use in 1941. This estimate is predicated on the assumptions that industrial consumption of kerosene shows a certain stability even in the face of increasing industrial activity, and that the allocation of kerosene for home use will be small in peacetime, and minimal in wartime. The estimates are thought to be subject to an error of about $\pm 25\%$, since they are unconfirmed by recent data. There is thought to be no substantial home consumption of products other than kerosene.

Consumption of Kerosene. The historical data shown in Table 27 have been assembled on kerosene consumption by homes and industry in the USSR. It has not been possible to separate the two consumers, since the two groups are combined in all available Russian statistics.

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Table 27. Kerosene Consumption in the USSR by
Industrial and Home Groups in g/
1913 - 1941

Year	Thousands of Metric Tons
1913	800 - 825.5
1925/26	778
1929/30	1530
1932	1696.1
1933	1294
1935	1048
1936 (Plan)	1300
1936 (Actual)	1482.5
1941 (Planned production)	1938.9

g/ See reference 63/ in the Annex for sources.

In several recent years, it is possible to learn something of the trends in consumption within the industrial-home group which brought about the changes indicated. In 1936, according to one Soviet source 64/, actual consumption of kerosene by the home group of consumers increased 28.1% over 1935, while the consumption of the industrial and technical group increased very little. Again, in the 1937 plan, the scheduled increase in consumption for the industrial and home groups was confined almost entirely to a 28.7% planned increase in the availability of kerosene to home consumers, with virtually no increase scheduled for industrial use 65/. Not enough information is available in these percentage factors to be able to determine the absolute consumption of either group. However, it may be inferred that industrial consumption of kerosene must have remained relatively constant in these years. This allows the establishment of a hypothesis that Soviet industrial consumption of kerosene is relatively constant, even in such a period of increasing industrial activity as 1935-37.

If this hypothesis is accepted, it follows that the major part of variations in kerosene consumption by the industrial-home group of consumers must be due to variations in the consumption by home consumers. The last year in which the actual kerosene consumption of the industrial-home group is known is 1936. However, the 1941 planned production for industrial and home users is also known. The 1941 planned production

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exceeds the 1936 actual consumption by some 450,000 metric tons. Hypothetically, then, this increase in production of kerosene must have been primarily scheduled to meet increased requirements of home consumers.

In accordance with the hypothesis, it may further be assumed that in post-war years, any increases in consumption beyond the 1941 levels would be largely due to further increases in the home consumption of kerosene. Since kerosene is used in the home mainly for heating, cooking, and lighting, this requirements would be determined by the number of homes burning kerosene, and the amount burned in each home. Between 1941 and 1950 there were considerable increases in the number of homes in the USSR, due both to population and territorial increases. However, in the same period, there was an increase in the number of homes served by electricity and natural gas. It therefore seems probable that the number of kerosene-burning homes has not increased proportionately to the total number of homes. With regard to the amount of kerosene currently burned per home, there is no evidence, other than a general indication that kerosene is generally in tight supply. It is certain that considerable flexibility is possible in the amount burned per home, since substitute fuels (wood, charcoal) are available to many kerosene consumers, and notably to rural kerosene consumers. It is also evident that the home requirement for kerosene is one which may be very readily controlled by the Soviet government through rationing without seriously affecting the ability of the Soviet economy to produce.

On balance, it seems that there is some basis for the assumption that the size of the home requirement for kerosene is no larger in 1950 than it was in 1941. Coupling this premise with the hypothesis that industrial consumption is not subject

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to serious variation, it seems possible to assert that 1950 consumption for kerosene for industrial and home consumers will not be larger than the production of kerosene planned for 1941. Total consumption in 1950 is therefore tentatively estimated to be 1.9 million metric tons. The degree of error possible here is considerable, since no recent concrete data are available to confirm the estimate. The error would seem not to exceed plus or minus 25%.

No concrete evidence is available on the current trends in civil kerosene consumption by industrial and home users. It may be possible to assume that kerosene consumption is relatively constant at the 1950 level of about 1.9 million tons. If, contrary to this assumption, the consumption is increasing, it may fairly be assumed that the increase is due largely to an increased generosity on the part of the Soviet government in making more kerosene available to home users. This is not believed to be the case. It seems more prudent to assume that the USSR would prefer the stockpiling of kerosene and jet fuel to increasing the kerosene ration to civilians.

Since the estimates of post-war kerosene consumption are based on the 1941 planned production of kerosene (which was only partially carried out) and since it has been assumed that there exists a great deal of flexibility in the home demand for kerosene, it follows that in wartime it would be consistent to assume that a drastic cut in kerosene consumption would be possible. This cut would fall in the area of the home group of consumers. The industrial group would show much less flexibility in their requirements. At the moment, it is impossible to determine what the minimum industrial requirements might be. However, it does not seem illogical to consider that overall industrial and home consumption could be cut by

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as much as 50% without harm to the economy. Wartime consumption has therefore been arbitrarily estimated at 1.0 million metric tons. This estimate should be subject to about the same range of error as the peacetime estimates, or 25%.

It is not believed that any significant amounts of other products were used by home consumers in the USSR. Earlier estimates have indicated that some fuel oil was used in heating homes. No evidence has been found to substantiate this assumption. On the contrary, evidence presented by Soviet defectors seems to indicate that this is not the case. It must be understood that only fuel oil consumption in homes is referred to herein. It is known that fuel oil is used to heat certain office and industrial buildings, and government buildings. In view of the closer affinity of these types of building to industry, it is considered in this report that the fuel oil allocated to industry covers this type of requirement.

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7. Consumption of Petroleum Products by Air Transport.

Table 28 presents the best estimate now available of the consumption of aviation grade gasolines of all types by civil air transport in the Soviet Union. Included in these totals are consumption estimates for scheduled commercial air transport, for non-scheduled civil air transport, and for miscellaneous air operations. These estimates have been prepared on the basis of estimates of the number and type of aircraft engaged in civil operations in the USSR, their fuel consumption per hour, and their average number of flying hours per year.

TABLE 28. Estimated Consumption of Petroleum Products
by Civil Air Transport in the USSR
1950 - 1953

	1950	1951	Peace 1952	Million Metric Tons		sc
				Fiscal 1953	War Fiscal 1953	
Gasoline	.4	.4	.5	.5	a/	

a/ Negligible.

The analysis on which the estimates of consumption by civilian air transport are based is one prepared by the Directorate of Intelligence, USAF, for the year 1951 66/. This analysis is presented in detail in Table 29, Appendix and notes included therewith.

1950 consumption has been assumed to be about the same as in 1951. 1952 and fiscal 1953 peacetime consumption has been arbitrarily increased somewhat. In wartime fiscal 1953, it is considered that almost all of the aircraft presently engaged in civil air transport will be transferred to the military; civil air transport requirements are therefore considered to be negligible in wartime.

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It is apparent that there will also exist a demand for aviation lubricants for civil aviation in all the years for which a civilian aviation gasoline consumption estimate appears. While this demand for specialized lubricants is important in terms of their availabilities, the volume of demand for these products for civil air transport is very small.

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APPENDIX

TABLE 12. Estimated Composition by Sources of the USSR Tractor Park
1950-1953

	Thousand Units			
	1950	1951	1952	1953
Tractors from pre-war production	206	124	60	-
Tractors obtained by requisition, reparations	23	21	18	14
Tractors obtained from UNRRA and lend-lease	10	10	10	10
Tractors produced in USSR, 1945 to 1948	112	112	112	110
Tractors produced in 1949	78	78	78	78
Tractors produced in 1950	-	82	82	82
Tractors produced in 1951	-	-	62	62
Tractors produced in 1952	-	-	-	60
Full use equivalent of tractors produced in specified year	33	25	24	24
Total	462	462	436	440

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TABLE 13. Estimated Horsepower of the Soviet Tractor Park
1950-1953

Year	Source of Tractor	Number of Tractors (in Thousands)	Average Horsepower per tractor	Total Horsepower (in Thousands)
1950	Pre-War	206	20	4,120
	Requisitioned & Reparations	23	30	690
	Lend-Lease & UNRRA	10	30	300
	1945-1948 Production	112	31	3,472
	1949 Production	78	32	2,496
	Full-use equivalent 1950 production	33	33	1,089
	Total	462		12,167
1951	Pre-war	124	20	2,480
	Requisitioned & Reparations	21	30	630
	Lend Lease & UNRRA	10	30	300
	1945-1948 production	112	31	3,472
	1949 production	78	32	2,496
	1950 production	82	33	2,706
	Full-use equivalent 1951 production	25	33	825
	Total	452		12,909
1952	Pre-war	50	20	1,000
	Requisitioned & Reparations	18	30	540
	Lend-lease & UNRRA	10	30	300
	1945-1948 production	112	31	3,472
	1949 production	78	32	2,496
	1950 production	82	33	2,706
	1951 production	62	33	2,046
	Full-use equivalent 1952 production	24	34	816
	Total	436		13,376
1953	Pre-war	0	0	0
	Requisitions & Reparations	14	30	420
	Lend-Lease & UNRRA	10	30	300
	1945-1948 production	110	31	3,410
	1949 production	78	32	2,496
	1950 production	82	33	2,706
	1951 production	62	33	2,046
	1952 production	60	34	2,040
	Full use equivalent 1953 production	24	35	840
	Total	440		14,258

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TABLE 14. Estimated Consumption of Petroleum Products by
USSR Agricultural Tractors
1950-1953

	1950	1951	1952	1953
<u>Diesel Tractors</u>				
Total Horsepower (HP)	3,041,750	3,872,700	4,682,000	5,933,000
Fuel Consumption per HP (tons)	0.445	0.445	0.445	0.445
Total fuel requirement (tons)	1,354,000	1,724,000	2,084,000	2,666,000
<u>Non-Diesel Tractors</u>				
Total Horsepower	9,125,250	9,036,300	8,694,000	8,270,000
Fuel Consumption per HP	0.536	0.536	0.536	0.536
Total fuel requirement tons	4,891,000	4,843,000	4,660,000	4,433,000
<u>All Tractors</u>				
Total Horsepower	12,167,000	12,909,000	13,365,000	14,253,000
Fuel Consumption per HP	0.039	0.039	0.039	0.039
Total fuel requirement	475,000	503,000	522,000	556,000

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TABLE 17. Estimated 1951 Inventory of the Soviet Deep Sea Merchant Fleet

A. Composition of the Entire Fleet		No. of Vessels	Tonnage GRT a/			
1. Vessels over 1000 Gross tons						
Coal burning steam	333	878,217				
Oil burning steam	111	657,069				
Diesel powered	125	421,660				
Total	569	1,956,946				
2. Vessels under 1000 Gross tons						
Diesel powered (30%)	126	59,400				
Other (70%)	293	138,400				
Total	419	197,800				
Grand Total	988	2,154,746				
B. Composition of the Petroleum Fueled Fleet						
	Oil Burning Steam	Diesel powered	Total			
1. Vessels over 1000 Gross Tons	No. of Vessels	GRT a/	No. of Vessels	GRT a/	No. of Vessels	GRT a/
Cargo						
a. "Liberty" type (7175 GRT)	38	272,650	-	-	38	272,650
b. Other types	53	246,634	72	184,832	125	431,466
Tankers	5	21,175	25	101,013	30	122,188
Combination	14	103,838	21	124,125	35	227,963
Miscellaneous	1	12,772	7	11,690	8	24,462
Total	111	657,069	125	421,660	236	1,078,729
2. Vessels under 1000 gross tons						
Diesel powered	-	-	126	59,400	126	59,400
Grand Total	111	657,069	251	481,060	362	1,138,129

a/ Gross Rated Tons.

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TABLE 19: Estimated 1951 Inventory of the Soviet Caspian Sea Merchant Fleet

	Oil burning Steam		Diesel powered		Total	
	No. of vessels	GRT a/	No. of vessels	GRT a/	No. of vessels	GRT a/
A. Vessels over 1000 GRT a/						
1. Vessels on which reasonable intelligence exists						
Tankers	40	58,500	22	104,600	62	163,100
Freighters and others	13	16,900	10	116,400	23	33,300
2. Hypothetical distribution of remaining vessels						
Tankers	30	113,500	-	-	30	113,500
Freighters and others	4	11,000	-	-	4	11,000
3. Totals						
Tankers	70	172,000	22	104,600	92	276,600
Freighters and others	17	27,900	10	116,400	27	44,300
Total	87	199,900	32	121,000	119	320,900
B. Vessels under 1000 GRT a/						
Estimated 10% of over 1000 GRT tonnage	-	-	-	32,000	-	32,000
GRAND TOTAL TONNAGE		199,900		153,000		352,900
a/ Gross Rated Tons.						

TABLE 21. Calculations of the Consumption of Petroleum Products
by the Soviet River Fleet, 1951-1953

	1951	Peace 1952	Fiscal 1953	War Fiscal 1953
<u>Fuel Oil</u>				
Horsepower	403,000	430,000	443,000	443,000
Hours of Operation	1,790	1,790	1,790	1,970
Total HP/Hour	721,370,000	769,700,000	792,970,000	872,710,000
Fuel Oil consumption (metric tons) @ .000223 MT/HP/Hour	161,000	172,000	177,000	195,000
<u>Diesel Fuel</u>				
Horsepower	201,000	214,000	221,000	221,000
Hours of operation	1,790	1,790	1,790	1,970
Total HP/Hour	359,790,000	383,060,000	395,590,000	435,370,000
Diesel consumption (metric tons) @ .000312 MT/HP/Hour	112,000	120,000	123,000	135,000
<u>Lubricants</u>				
Diesel consumption (metric tons)	112,000	120,000	123,000	135,000
Fuel oil consumption (metric tons)	161,000	172,000	177,000	195,000
Total	273,000	292,000	300,000	330,000
5% of above	14,000	15,000	15,000	16,000
Total lubricant consumption (metric tons) (133% of above)	19,000	20,000	20,000	21,000

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TABLE 26. Availability of Fuel Oil for Industrial and Other Uses, USSR, 1950-1953

	Million Metric Tons				
	Peace				War
	1950	1951	1952	Fiscal 1953	Fiscal 1953
Crude production (Well-head)	37.5	41.0	44.0	45.4	45.4
Runs to stills	35.6	39.0	41.8	43.1	43.1
Fuel oil yield (29.9%)	10.6	11.7	12.5	12.9	12.9
Fuel oil from imported mazut	.5	.5	.5	.5	.5
Fuel oil from shale	.5	.5	.5	.5	.5
Total available fuel oil	11.6	12.7	13.5	13.9	13.9
Less: 2% product loss	.2	.2	.3	.3	.3
	11.4	12.5	13.2	13.6	13.6
Military requirements (Navy)	.4	.4	.4	.4	3.0
Railroad requirements	1.8	1.8	1.8	1.8	1.8
Shipping requirements	1.2	1.2	1.2	1.2	1.1
Sub-total	3.0	3.1	3.8	10.2	7.7
Plus:					
1% of crude produced burned as fuel in the oil fields	.4	.4	.4	.5	.5
Total	3.4	3.5	10.2	10.7	8.2

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TABLE 29. Total Annual Fuel Consumption of Civilian Soviet Transport Aircraft, 1951

Soviet Aircraft Category and Number of Transport Aircraft	Average Fuel Consumption per hr (US Gallons)	Average Number of Flying Hours Per Aircraft per Yr.	Total consumption per year in U.S. gallons			Total Requirements in Metric Tons ^{a/} Incl. 10% allowance for Logistic loss		
			Total by type	b/ Scheduled	b/ Non-Scheduled	Total by type	b/ Scheduled	b/ Non-Scheduled
1. Civil Air Transport								
1250 LI-2's (2 Engine)	92	600	69,000,000	54,444,000	50,256,000	207,207	163,495	150,919
350 IL-12's (2 Engine)	170	600	35,700,000			107,207		
2. Miscellaneous Transports ^{c/}								
2270 PO-2 YAR-6,8,12,14,16 SHCHE-2 GST MI-6 AN-2	20 d/	300	13,620,000					40,901
TOTAL							163,495	191,820

^{a/} Footnotes for Table 29 follow on p. 72.

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- a/ In computing these figures it has been assumed that one metric ton equals 352.3 US gallons for all types of fuels.
- b/ In arriving at these figures, the ratio of scheduled to non-scheduled operations was based on a comparison of the 1950 Aeroflot schedule with total current operations. The 1951 schedule was not available. These totals do not reflect the unknown results of the recent fuel economy program in the Civil Air Fleet.
- c/ The total of "Miscellaneous Transports" includes aircraft of the types listed which are used for such non-transport activities as training, aerological research, photographic reconnaissance, liaison, research and development, police work, and so forth.
- d/ Though several of the aircraft types included in this miscellaneous category consume more than 20 gallons of fuel per hour (e.g., YAK-16, and GST), the average has been reduced by the fact that the PO-2, which consumes about 8 gallons per hour, constitutes the major portion of the total number of aircraft considered.

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